

**SERIES CONNECTOR FOR WINDING ENDS OF  
A DYNAMOELECTRIC MACHINE AND ASSOCIATED METHODS**

**Field of the Invention**

The present invention relates to the field of dynamoelectric machines and, more specifically, to rotor winding series connectors for such machines.

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**Background of the Invention**

An electrical power generator converts mechanical energy into electrical energy. A typical electrical power generator includes a stator and a rotor that rotates within the stator to thereby generate electricity.

10 The rotor, in turn, is mounted to a shaft that drives the rotor. An exciter may be positioned adjacent the generator to provide current to the generator rotor. The exciter generally includes an exciter stator and an exciter rotor that rotates within the exciter stator. The exciter rotor, in turn, is mounted to the shaft that drives the generator rotor. Together, the  
15 generator, shaft, and exciter may be considered as a typical generator apparatus.

An exciter is but one example of a dynamoelectric machine. Rotor windings for such a machine may be metallic bar conductors. During a winding refurbishing operation, new rotor windings are installed into the  
20 rotor body and opposing first and second rotor winding ends are connected. Referring, for example to FIG. 5, a prior art connection is shown between the opposing first and second rotor winding ends. More

specifically, a plurality of first rotor winding ends **10a-10n** are connected to respective second rotor winding ends **11a-11n**. The first plurality of rotor winding ends **10a-10n** are bent downwardly, and the second corresponding plurality of rotor winding ends **11a-11n** are bent upwardly to be adjacent the first plurality of rotor winding ends in pairs. The manual bending of the rotor winding ends **10a-10n**, **11a-11n** may be tedious and labor intensive.

After each pair of first and second rotor winding ends **10a-10n**, **11a-11n** are bent to a predetermined position, a joint **14** is brazed between adjacent surface portions. Each brazed joint **14** may need to first cool before connecting successive rotor winding ends. Accordingly, the current approach to making series connections for the winding ends is relatively difficult, time consuming, and expensive.

### **Summary of the Invention**

It is therefore an object of the present invention to provide a connector for efficiently connecting rotor winding ends on a dynamoelectric machine.

This and other objects, features and advantages of the present invention are provided by a rotor winding series connector for connecting rotor winding ends. More specifically, the rotor winding series connector may be for a dynamoelectric machine comprising a rotor and a stator surrounding the rotor. The rotor may comprise rotor windings defining at least one pair of first and second rotor winding ends arranged in spaced relation. The rotor winding series connector may comprise a C-shaped connector body having a medial connector portion and respective first and second end connector portions extending outwardly from the medial connector portion.

First and second end connector brackets may be carried by the respective first and second end connector portions for receiving the respective first and second rotor winding ends. The C-shaped connector body may comprise flexible conductive material arranged in a plurality of

stacked layers to facilitate installation. The series connector advantageously eliminates the need to precisely manually bend the winding ends and speeds refurbishing, for example.

5           The rotor winding series connector may comprise insulating material adjacent outer surface portions of the C-shaped connector body and/or the first and second connector brackets. The C-shaped connector body may comprise copper. Each of the first and second brackets may have an L-shape with a first leg extending outwardly from adjacent portions of the respective first and second end connector portions of the C-shaped  
10       connector body, and a second leg extending generally parallel thereto. The winding ends can be readily positioned into the brackets.

          For a typical installation, such as a generator exciter, a plurality of pairs of first and second rotor winding ends may be connected by a plurality of rotor winding series connectors. More specifically,  
15       pluralities of first and second rotor winding ends may be arranged in respective stacks, and a rotor winding series connector may connect each pair of first and second rotor winding ends. Spacing between successive pairs of the first and second rotor winding ends may progressively increase. Accordingly, successive ones of the plurality of rotor winding  
20       series connectors may have respective medial portions having progressively increasing lengths corresponding to the progressively increasing spacings. A respective brazed joint may be provided between each of the C-shaped connector bodies and adjacent portions of each of the first and second rotor winding ends.

25           A method aspect of the present invention is directed to using the rotor winding series connector to connect, in series, at least one pair of first and second rotor winding ends arranged on the rotor in spaced relation. The method may comprise positioning the respective first and second rotor winding ends into the respective first and second connector  
30       brackets to thereby connect the respective first and second rotor winding ends together in series. The method may also comprise selecting the rotor winding series connector so that the medial connector portion has a length

corresponding to the space between the rotor winding ends. The method may further comprise brazing a respective joint between the C-shaped connector body and adjacent portions of the first and second rotor winding ends.

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#### **Brief Description of the Drawings**

Fig 1 is a schematic diagram of a generator apparatus including series connectors for winding ends of an exciter according to the present invention.

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FIG. 2 is a schematic side elevation view of a plurality of rotor winding series connectors according to the present invention with the insulation removed for clarity of illustration.

FIG. 3 is a cross sectional view taken through line 3--3 of FIG. 2.

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FIG. 4 is a cross sectional view taken through line 4--4 of FIG. 2 with the winding end removed for clarity of illustration.

FIG. 5 is a schematic side elevation view of a plurality of rotor winding ends connected according to the prior art.

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#### **Detailed Description of the Preferred Embodiments**

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these

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embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

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Referring initially to FIG. 1, a generator apparatus 20 including a rotor winding series connector 40a in accordance with the present invention is now described. The generator apparatus 20 illustratively includes a generator 21 comprising a shaft 22, and a generator

rotor **24** carried by the shaft. A generator stator **26** illustratively surrounds the generator rotor **24**. More specifically, the generator rotor **24** rotates within the generator stator **26** to generate electricity. The shaft **22** may be rotated by mechanical energy provided by a steam, water, or combustion turbine, for example, as will be appreciated by those skilled in the art.

The generator apparatus **20** also illustratively includes an exciter **25**, which is but one example of a dynamoelectric machine. The exciter **25** illustratively comprises an exciter rotor **32** carried by the shaft **22**, and an exciter stator **34** surrounding the exciter rotor. The exciter **25** supplies electrical power for the generator rotor **24** as will be understood by those skilled in the art.

Referring now additionally to FIGS. 2-4, the exciter rotor **32** illustratively comprises rotor windings defining pairs of first rotor winding ends **38a-38n** and second rotor winding ends **39a-39n** arranged in spaced relation. The rotor windings may comprise a metallic bar conductor, such as copper, for example, or another type of metallic conductor, as understood by those skilled in the art. The metallic bar conductor may be between about 1.5 to 2.5 inches wide by about 0.25 to 0.75 inches thick, but may be any size, as understood by those skilled in the art. The spaced relation between the rotor winding ends **38a-38n**, **39a-39n** is illustratively a radially spaced relation.

Each rotor winding series connector **40a-40n** illustratively connects the pair of rotor winding ends **38a-n**, **39a-n** together in series. Each rotor winding series connector **40a-40n** illustratively has a C-shaped connector body **42a-42n** having a medial connector portion **44a-44n**, a first end connector portion **46a-46n**, and a second end connector portion **47a-47n**, both of which extend outwardly from the medial connector portion. Each rotor winding series connector **40a-40n** also illustratively includes first connector brackets **48a-48n** and second connector brackets **49a-49n** carried by the respective first and second end connector portions **46a-46n**, **47a-47n**. The first and second end connector brackets **48a-48n**, **49a-49n** illustratively receive the respective first and second rotor winding ends **38a-**

**38n, 39a-39n** therein. A brazed joint or weld **55** is provided between each of the rotor winding ends **38a-38n, 39a-39n**, and adjacent portions of the rotor winding series connectors **40a-40n**.

5 The plurality of first rotor winding ends **38a-38n** and second rotor winding ends **39a-39n** are each illustratively arranged in stacked relation. Accordingly, a corresponding plurality of rotor winding series connectors **40a-40n** connects each pair of the first and second rotor winding ends **38a-38n, 39a-39n**. Although a plurality of rotor winding series connectors **40a-40n** connecting a plurality of first and second rotor winding ends **38a-38n, 39a-39n** are illustrated, those skilled in the art will appreciate that for some embodiments only, one rotor winding series connector may be provided to connect a single pair of first and second rotor winding ends. Those skilled in the art will further appreciate that the rotor winding series connectors **40a-40n** may be used on any  
10 dynamoelectric machine, especially larger dynamoelectric machines where considerable labor may be required to bend rotor windings.  
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The plurality of first and second rotor winding ends **38a-38n, 39a-39n** illustratively defines progressively increasing spacings therebetween. The progressively increasing spacings between the plurality of first and second rotor end windings **38a-38n, 39a-39n** are progressively increasing radial spacings. The respective medial connector portions **44a-44n** of the plurality of rotor winding series connectors **40a-40n** have progressively larger lengths to correspond to the progressively increasing radial spacings.  
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25 Insulating material **50** (FIG. 3-4) is positioned between adjacent ones of the plurality of first rotor end windings **38a-38n**, the second rotor end windings **39a-39n**, and between adjacent ones of the plurality of rotor winding series connectors **40a-40n**. The rotor windings are illustrated in FIG. 2 as being spaced apart, but those skilled in the art will appreciate that very little, if any, space is provided between the rotor windings after the insulating material **50** is applied to the first and second rotor end windings **38a-38n, 39a-39n**, and the rotor winding series  
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connectors **40a-40n**. Insulating material **50** is also illustratively positioned adjacent outer surface portions of the C-shaped connector body **42a-42n**, and/or the first and second connector brackets **48a-48n**. The insulating material **50** may, for example, be a plastic material, or any other type of insulator.

Referring now more specifically to FIGS. 3-4, one of the rotors winding series connectors **40n** will be described in greater detail, for clarity of explanation. It should be readily understood by those skilled in the art, however, that the following description of the rotor winding series connector is applicable to all the rotor winding series connectors illustrated in FIG. 2, for example. The C-shaped connector body **42n** comprises conductive material that is preferably flexible. The conductive material illustratively comprises a plurality of stacked metal layers **70-76**. Each of the stacked metal layers **70-76** may, for example, be copper, or another flexible conductive material, as understood by those skilled in the art. More specifically, the stacked metal layers **70-76** are moveable with respect to one another, to advantageously increase flexibility. Although the stacked metal layers **70-76** are movable with respect to one another, they are preferably connected along an end portion by a brazed or spot welded joint, for example, or any other type of joint. A total of seven stacked metal layers **70-76** are illustrated, but those skilled in the art will appreciate that any number of metal layers may be used to form the C-shaped connector body **42n**.

The connector bracket **48n** illustratively has an L-shape. An end portion of the connector bracket **48n** is connected to an adjacent portion of the C-shaped connector body **42n**. The connector bracket **48n** may be connected to the C-shaped connector body **42n** by a brazed joint, a spot welded joint, or any other type of joint, as understood by those skilled in the art. More specifically, the connector bracket **48n** has a first leg **52** extending outwardly from adjacent portions of the end connector portion **46n** of the C-shaped connector body **42n**. The connector bracket **48n** also illustratively has a second leg **54** extending generally parallel to

the end connector portion **46n** of the C-shaped connector body **42n**. The second leg **54** may be angled inwardly (illustrated by a dashed line) towards the end connector portion **46n** to advantageously provide a more sturdy connection between the rotor winding series connector **40n** and the rotor winding end. Those skilled in the art will appreciate that the angle of the second leg **54** may vary depending on the size of the rotor end windings to be secured therein.

A method aspect for the present invention is for using a rotor winding series connector **40a-40n** to connect in series at least one pair of first and second rotor winding ends **38a-38n, 39a-39n**. The method may comprise positioning the respective first and second rotor winding ends **38a-38n, 39a-39n** into the respective first and second connector brackets **48a-48n, 49a-49n** to thereby connect the respective first and second rotor winding ends together in series.

The method may also include selecting the rotor winding series connector **40a-40n** so that the medial connector portion **44** has a length corresponding to the space between the rotor winding ends **38a, 38b**. The method further includes brazing at least one joint **55** between the C-shaped connector body **42a-42n** and adjacent portions of the first and second rotor winding ends **38a-38n, 39a-39n**.

Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed, and that other modifications and embodiments are intended to be included within the scope of the appended claims.